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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

INTERIM REPORT ON FREE-SPINNING CHARACTERISTICS OF A 1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE

TED NO. NACA AD 395

By James S. Bowman, Jr.

Langley Aeronautical Laboratory
Langley Field, Va.

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INTERIM REPORT ON FREE-SPINNING CHARACTERISTICS OF A 1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE

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SUMMARY

An investigation is being conducted in the Langley 20-foot free-spinning tunnel on a 1/24-scale model of the Grumman F11F-1 airplane to determine spin and recovery characteristics and the minimum-size parachute required to satisfactorily terminate the spin in an emergency. Results obtained to date are presented herein.

Test results indicate that it may be difficult to obtain an erect or inverted spin on the airplane, but, if a spin is obtained, the spin will be very oscillatory and recovery from the developed erect spin by rudder reversal may not be possible. The lateral controls will have no appreciable effect on recoveries from erect spins. Recovery from the inverted spin by merely neutralizing the rudder will be satisfactory. After recoveries by rudder reversal and after recoveries from spins without control movement (no spins), the model oftentimes rolled very rapidly about the X-axis.

Based on limited preliminary tests made in this investigation to make the model recover satisfactorily, it appears that canards near the nose of the airplane or differentially operated horizontal tails may be utilized to provide rapid recoveries.

The parachute test results indicate that an 11-foot-diameter (laid-out-flat) parachute with a drag coefficient of 0.650 (based on the laid-out-flat diameter) and with a towline length equal to the wing span is the minimum-size parachute required to satisfactorily terminate an erect or inverted spin in an emergency.

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INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, an investigation is being conducted in the Langley 20-foot free-spinning tunnel on a 1/24-scale model to determine the spin and recovery characteristics of the Grumman F11F-1 airplane.

The present report presents the test results obtained to date. Tests have been made for the landing gross-weight loading for both erect and inverted spins and the minimum-size parachute required to insure satisfactory recovery in an emergency has been determined. The erect spin tests were conducted for the normal center-of-gravity position (24 percent $\bar{c}$) and for a rearward position of 29.9 percent $\bar{c}$. The inverted spin tests and the parachute tests were conducted only for the rearward center-of-gravity position. Alternate recovery methods were tried and are discussed briefly in the text.

An appendix is included which presents a general description of the model testing technique, the precision with which model test results and mass characteristics are determined, variations of model mass characteristics occurring during tests, and a general comparison between model and airplane results.

SYMBOLS

b	wing span, ft
S	wing area, sq ft
$\bar{c}$	mean aerodynamic chord, ft
$x/\bar{c}$	ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord
$z/\bar{c}$	ratio of distance between center of gravity and fuselage reference line to mean aerodynamic chord (positive when center of gravity is below line)
m	mass of airplane, slugs
I_X, I_Y, I_Z	moments of inertia about X, Y, and Z body axes, respectively, slug-ft^2

$\frac{I_X - I_Y}{mb^2}$ inertia yawing-moment parameter

$\frac{I_Y - I_Z}{mb^2}$ inertia rolling-moment parameter

$\frac{I_Z - I_X}{mb^2}$ inertia pitching-moment parameter

ρ air density, slugs/cu ft

μ relative density of airplane, $\frac{m}{\rho S b}$

α angle between fuselage reference line and vertical (approximately equal to absolute value of angle of attack at plane of symmetry), deg

ϕ angle between span axis and horizontal, deg

V full-scale true rate of descent, ft/sec

Ω full-scale angular velocity about spin axis, rps

MODEL AND TEST CONDITIONS

A 1/24-scale model of the Grumman F11F-1 airplane was furnished by the Bureau of Aeronautics, Department of the Navy, and was checked for dimensional accuracy and prepared for testing by the Langley Laboratory of the National Advisory Committee for Aeronautics. A three-view drawing of the model as tested is shown in figure 1.

Lateral control is obtained on the F11F-1 airplane by upper-surface slotted spoilers (flaperons) instead of ailerons (fig. 1). The trim tabs on the wing tips were not used for these tests and were set for zero deflections throughout this investigation. The horizontal tail is an all-movable type with elevators. However, the elevators operate only when the flaps are down. The elevators were set for zero deflection for all tests. The wing fences as shown in figure 1 were used only in preliminary tests on the model and indicated no effect on the spin or recovery, and inasmuch as the fences were subject to much damage during model testing, they were removed from the model for the remainder of the tests. The F11F-1 airplane also has wing leading-edge slats which have not as yet been tested in the investigation. All tests were conducted with the model in the clean condition.

A photograph showing the model in the normal flying configuration is shown in figure 2. The dimensional characteristics of the airplane are presented in table I.

The model was ballasted to obtain dynamic similarity to the airplane at an altitude of 25,000 feet (ρ = 0.001065 slug/cu ft). The mass characteristics and inertia parameters for loadings possible on the airplane and for the loading tested on the model are indicated in table II.

The parachute tests were conducted with flat-type parachutes made of low-porosity material but which were made more stable by cutting holes in the fabric to allow more air to flow through the canopy. (The stability of parachutes is dependent upon the porosity of the material; see ref. 1.). The parachute point of attachment was at the bottom rear of the fuselage.

The maximum control deflections (measured perpendicular to the hinge lines) used on the model during the tests were:

Rudder, deg	25 right, 25 left
Flaperons, deg	55 up, 0 down
Horizontal tail, deg	18 up, 5 down

RESULTS AND DISCUSSION

The results of the model tests are presented in charts 1 through 3 and in table III. The model data are presented in terms of full-scale values for the airplane at an altitude of 25,000 feet. All tests were conducted with the model in the landing loading and for two center-of-gravity positions. Tests conducted for the rearward center-of-gravity position indicated that the model would spin similar to that of the normal center of gravity except that the duration of the spin was longer. For this reason, most of the test results were obtained for the rearward center-of-gravity position. Spins to the right and left were similar, and all test results are arbitrarily presented in terms of spins to the pilot's right.

Erect Spins

The erect spin-test results are presented in charts 1 and 2 for the normal center-of-gravity position of 24 percent mean aerodynamic chord (loading no. 1 in table II) and for a rearward center-of-gravity position of 29.9 percent mean aerodynamic chord (loading no. 2 in table II), respectively.

The test results indicate that it may be difficult to obtain a developed spin for this airplane, particularly for the normal center-of-gravity (24 percent $\bar{c}$) position. However, the test results indicate that, should a spin occur, the spin will be very oscillatory in roll and yaw and recovery by rudder reversal may not be possible. The model was less prone to spin with the horizontal tail in the down position (stick forward) than for the horizontal tail in the up position (stick back) indicating that movement of the stick full forward after rudder reversal may expedite recovery from any spin obtained. The positions of the flaperons had very little or no effect on the erect spin and offered no assistance in the spin recovery. These results are consistent with those reported in reference 2.

The model was less prone to spin for the normal center of gravity (24 percent $\bar{c}$) than for the rearward center-of-gravity position of 29.9 percent mean aerodynamic chord. Based on these results, spins should be more readily obtainable on the airplane for the rearward than for the normal center-of-gravity position.

Research currently being conducted at Langley has given indications that the use of properly placed extensible canard surfaces may be very effective as an emergency recovery device for some designs. Accordingly, brief tests were conducted on the current model utilizing surfaces shown in figure 3. Preliminary test results indicate that extension of these surfaces in conjunction with rudder reversal results in satisfactory recoveries.

Limited preliminary test results indicate that differentially operated horizontal tails may also provide rapid recoveries. Tests were made with the horizontal tails differentially set with the spin (right horizontal tail trailing edge up 40° and left trailing edge down 40° for right spin) and the model entered a "no spin" after each launch indicating that if the horizontal tail were moved in this manner, good recoveries should be obtained.

Inverted Spins

The results of the inverted-spin tests with the center of gravity in the rearward position are presented in chart 3. The results show that the model had a greater tendency to spin with the flaperons with the spin (stick left for spin to pilot's right) and the horizontal tail up with respect to the ground (stick forward) than for any other control setting. The recoveries by rudder neutralization from the criterion spin (flaperons set one-third maximum deflection with the spin, the horizontal tail set to two-thirds its full-up (relative to ground) deflection), were satisfactory.

Parachute Tests

The results of the tests performed to determine the minimum-size parachute required to insure satisfactory recovery in an emergency are presented in table III for the rearward center-of-gravity position of 29.9 percent mean aerodynamic chord. The erect spin-test results indicated that a 10-foot-diameter (laid-out-flat) parachute with a drag coefficient of 0.585 (based on the 10-foot laid-out-flat diameter) is the minimum size required to insure satisfactory recovery in an emergency from an erect spin. However, the results obtained for the inverted spins indicate that an 11-foot-diameter (laid-out-flat) parachute with a drag coefficient of 0.650 (based on the laid-out-flat diameter) is needed to insure satisfactory recovery from an inverted spin. Therefore, inasmuch as a larger parachute is needed for the inverted spins, it is recommended that an 11-foot-diameter parachute with a drag coefficient of 0.650 be used for all spin demonstration tests. The towline length used for all tests was equal to the wing span. The results indicated that the airplane will have a tendency to roll after the recovery as long as the parachute is still attached to the airplane if the right or left flaperon is deflected. It is recommended, therefore, that all control be put to neutral during recovery by parachute action.

Landing Condition

Landing condition tests were not included in this investigation inasmuch as current Navy specifications require this type of airplane to demonstrate satisfactory recoveries in the landing condition from only 1-turn spins. At the end of one turn, the airplane will still be in an incipient spin from which recoveries are more readily obtained than from fully developed spins.

An analysis of model tests to determine the effect of landing flaps and landing gear (ref. 3) and the effect of leading-edge slats (ref. 4) indicates that in the event a spin is entered in the landing condition, the flaps and landing gear should be retracted and recovery attempted immediately. If possible the leading-edge slats should be left in the extended position.

Additional Remarks

The model exhibited a characteristic of rolling very rapidly about the X-axis after the spin was terminated either by control movement or without control movement (no spin). This rapid roll was obtained for most control settings (even when lateral controls were neutral) and for both center-of-gravity positions tested. The direction of roll was, in every case, the opposite direction to the spin, i.e., the model rolled right from left spins and rolled left from right spins. The roll was generally entered from high angles of attack and from an undamped oscillation in roll. The rate of roll ranged from a high of approximately 0.5 rps to 0.3 rps (full scale).

CONCLUSIONS

Based on the results of tests of a 1/24-scale model of the Grumman F11F-1 airplane, the following conclusions regarding the spin and recovery characteristics of the airplane at an altitude of 25,000 feet are made:

1. Test results indicate that it may be difficult to obtain a developed spin for this airplane, particularly for the normal center-of-gravity position. The tendency to spin will be greater when the center of gravity is in the most rearward position than when the center of gravity is in the normal position. Any developed spin obtained will be very oscillatory in roll and yaw.

2. The rudder will be ineffective in producing recovery from an erect spin. The lateral controls will have no appreciable effect on the erect spin and will be of no assistance in the spin recovery.

3. Recoveries from inverted spins even by merely neutralizing the rudder will be satisfactory.

4. An 11-foot-diameter (laid-out-flat) parachute with a drag coefficent of 0.650 (based on the laid-out-flat diameter) is the minimum size parachute required to insure satisfactory recovery from both erect and inverted spins in an emergency.

5. Based on limited tests conducted in this investigation, the use of canards near the nose of the airplane or the use of differentially operated horizontal tails appear promising as a means of insuring satisfactory recovery characteristics.

6. After recoveries by rudder reversal and after recoveries from spins without control movement (no spins), the model oftentimes rolled very rapidly about the X-axis.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., July 8, 1955.

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APPENDIX

TESTING TECHNIQUE AND MODEL PRECISION

Model Testing Technique

The operation of the Langley 20-foot free-spinning tunnel is generally similar to that described in reference 5 for the Langley 15-foot free-spinning tunnel except that the model-launching technique is different. With the controls set in the desired position, a model is launched by hand with rotation into the vertically rising air stream. After a number of turns in the established spin, a recovery attempt is made by moving one or more controls by means of a remote-control mechanism. After recovery, the model dives into a safety net. The tests are photographed with a motion-picture camera. The spin data obtained from these tests are then converted to corresponding full-scale values by methods described in reference 5.

Spin-tunnel tests are usually performed to determine the spin and recovery characteristics of a model for the normal spinning-control configuration (elevator full up, lateral controls neutral, and rudder full with the spin) and for various other lateral controls and elevator combinations including neutral and maximum settings of the surfaces. Recovery is generally attempted by rapid full reversal of the rudder, by rapid full reversal of both rudder and elevator, or by rapid full reversal of the rudder simultaneously with moving ailerons to full with the spin. The particular control manipulation required for recovery is generally dependent on the mass and dimensional characteristics of the model (refs. 6, 7, and 8). Tests are also performed to evaluate the possible adverse effects on recovery of small deviations from the normal control configuration for spinning. For these tests, the elevator is set at either full up or two-thirds of its full-up deflection and the lateral controls are set at one-third of full deflection in the direction conducive to slower recoveries, which may be either against the spin (stick left in a right spin) or with the spin depending primarily on the mass characteristics of the particular model. Recovery is attempted by rapidly reversing the rudder from full with the spin to only two-thirds against the spin, by simultaneous rudder reversal to two-thirds against the spin, and movement of the elevator to either neutral or two-thirds down, or by simultaneous rudder reversal to two-thirds against the spin and stick movement to two-thirds with the spin. This control configuration and manipulation is referred to as the "criterion spin," with the particular control settings and manipulation used being dependent on the mass and dimensional characteristics of the model.

Turns for recovery are measured from the time the controls are moved to the time the spin rotation ceases. Recovery characteristics of a model are generally considered satisfactory if recovery attempted from the criterion spin in any of the manners previously described is accomplished within $2\frac{1}{4}$ turns. This value has been selected on the basis of full-scale-airplane spin-recovery data that are available for comparison with corresponding model test results.

For recovery attempts in which a model strikes the safety net while it was still in a spin, the recovery is recorded as greater than the number of turns from the time the controls were moved to the time the model struck the net, as >3. A >3-turn recovery, however, does not necessarily indicate an improvement over a >7-turn recovery. When a model recovers without control movement (rudder held with the spin), the results are recorded as "no spin." An ∞ is used to indicate that the model continued spinning for 10 or more turns after the controls were moved for recovery.

For spin-recovery parachute tests, the minimum-size tail parachute required to effect recovery within $2\frac{1}{4}$ turns is determined. The parachute is opened for the recovery attempts by actuating the remote-control mechanism and the rudder is held with the spin so that recovery is due to the parachute action alone. The folded spin-recovery parachute is placed on the model in such a position that it does not seriously influence the established spin. A rubber band holds the packed parachute to the model and when released allows the parachute to be blown free of the model. On full-scale parachute installations it is desirable to mount the parachute pack within the airplane structure, if possible, and it is recommended that a mechanism be employed for positive ejection of the parachute.

Precision

Results determined in free-spinning tunnel tests are believed to be true values given by models within the following limits:

α, deg	± 1
ϕ, deg	± 1
V, percent	± 5
Ω, percent	± 2
Turns for recovery obtained from motion-picture records	$\pm\frac{1}{4}$
Turns for recovery obtained visually	$\pm\frac{1}{2}$

The preceding limits may be exceeded for certain spins in which it is difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin.

The accuracy of measuring the weight and mass distribution of models is believed to be within the following limits:

Weight, percent	±1
Center-of-gravity location, percent $\bar{c}$	±1
Moments of inertia, percent	±5

Controls are set with an accuracy of ±1°.

Variations in Model Mass Characteristics

Because it is impracticable to ballast models exactly and because of inadvertent damage to models during tests, the measured weight and mass distribution of the Grumman F11F-1 model varied from the true scaled-down values within the following limits:

Weight, percent	1 to 2 high
Center-of-gravity location, percent $\bar{c}$	1 to 2 rearward
Moments of inertia:	
I_X, percent	5 to 7 high
I_Y, percent	1 to 2 high
I_Z, percent	3 to 4 high

Comparison Between Model and Airplane Results

Comparison between model and full-scale results in reference 9 indicated that model tests accurately predicted full-scale recovery characteristics approximately 90 percent of the time and that for the remaining 10 percent of the time, the model results were of value in predicting some of the details of the full-scale spins, such as motions in the developed spin and proper recovery techniques. The airplanes generally spun at an angle of attack closer to 45° than did the corresponding models. The comparison presented in reference 9 also indicated that generally the airplanes spun with the inner wing tilted more downward and with a greater altitude loss per revolution than did the corresponding model, although the higher rate of descent was found to be generally associated with the smaller angle of attack regardless of whether it was for the model or the airplane.

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TABLE I.- DIMENSIONAL CHARACTERISTICS OF A 1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE

Overall length, ft	40.83
Wing:	
Span, overall, ft	31.63
Span, folded, ft	27.33
Area, sq ft (exclusive of leading-edge extension)	250
Mean aerodynamic chord, in.	98.38
Location leading edge of $\bar{c}$, fuselage station	248.08
Airfoil section:	
Root	NACA 65A006 Mod
Tip	NACA 65A004 Mod
Sweepback at 0.25-chord line, deg	35
Incidence, deg	0
Dihedral, deg	-2.5
Aspect ratio	4.0
Taper ratio	0.50
Flaperons:	
Area, sq ft	21.3
Span (perpendicular to fuselage center line), percent b/2	61.7
Trailing edge, percent wing chord	84
Hinge, percent wing chord	70
Trimmers:	
Area, sq ft	2.1
Location, wing station, in.	
Root	163
Tip	Wing tip
Hinge line, fuselage station, in.	375.41
Travel:	
Up, deg	5
Down, deg	5
Leading-edge slats:	
Location, wing station, in.	
Inboard	75
Outboard	Wing tip
Chord, percent wing chord:	
Root	10
Tip	10
Travel:	
Down, deg	20

TABLE I.- DIMENSIONAL CHARACTERISTICS OF A 1/24-SCALE

MODEL OF THE GRUMMAN F11F-1 AIRPLANE - Concluded

Flaps:	
Type	Slotted
Span, ft	11.06
Leading edge, percent wing chord	80
Trailing edge, percent wing chord	100
Hinge line, percent wing chord	83.3
Travel:	
Up	0
Down	40
Fence:	
Area, sq ft (total)	5.128
Location, (from center of fuselage), in.	75
Horizontal tail:	
Airfoil section (parallel to fuselage center line):	
Root	NACA 65A006
Tip	NACA 65A004
Area, sq ft	65.5
Span, ft	15.17
Sweep at 25 percent chord, deg	35
Aspect ratio	3.5
Taper ratio	0.4
Elevator (operative only when flaps are down):	
Area, sq ft	10.9
Hinge line, percent horizontal tail chord	75
Travel, moves down only, deg (measured from plane of horizontal tail):	
When horizontal tail is 0°	1
When horizontal tail is -8°	6.5
When horizontal tail is -15°	19.3
When horizontal tail is -18°	30
Vertical tail:	
Area, total, sq ft (exposed)	34.8
Airfoil section:	
Root	NACA 0006
Tip	NACA 0006
Rudder:	
Area, sq ft	7.27

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TABLE II.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADINGS POSSIBLE ON THE GRUMMAN F11F-1 AIRPLANE AND FOR THE LOADING TESTED ON THE 1/24-SCALE MODEL

[Model values given are converted to full scale; moments of inertia are given about the center of gravity.]

No.	Loading	Weight, lb	Center-of-gravity location		Relative density, μ		Moments of inertia, slug-ft^2			Mass parameters		
			$x/\bar{c}$	$z/\bar{c}$	Sea level	25,000 ft	I_X	I_Y	I_Z	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z - I_X}{mb^2}$
	Airplane values											
	Catapult	19,500	0.2568	0.0373	32.21	71.93	11,003	36,097	45,085	-414×10^{-4}	-148×10^{-4}	562×10^{-4}
	Flight (normal c.g.)	16,500	0.2432	0.0321	27.26	60.86	6,240	34,894	39,335	-559	-87	646
	Flight (most forward c.g.)	16,500	0.2401	0.0325	27.26	60.86	6,239	34,887	39,327	-559	-87	646
	Flight (most aft c.g.)	16,500	0.2901	0.0328	27.26	60.86	6,251	34,862	39,341	-558	-87	645
	Landing	14,100	0.2400	0.0414	23.29	52.01	6,066	30,911	35,407	-567	-103	670
	Model values											
1	Landing loading (normal c.g.)	14,311	0.256	0.0378	23.62	52.73	6,467	31,325	36,708	-571×10^{-4}	-121×10^{-4}	692×10^{-4}
2	Landing loading (most aft c.g.)	14,284	0.299	0.0261	23.60	52.69	6,373	31,477	35,531	-566	-91	657

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5121

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TABLE III.- SPIN-RECOVERY PARACHUTE DATA OBTAINED WITH A

1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE

[Landing-gross-weight loading with center of gravity at 29.9 percent mean aerodynamic chord; rudder fixed full with the spin and recovery attempted by opening the parachute alone; model values converted to corresponding full-scale values]

Parachute diameter, ft (a)	Drag coefficient, C_D (b)	Towline length, ft	Flaperons, deg	Horizontal tail, deg	V, ft/sec	α, deg	Ω, rev/sec	Turns for recovery
Right erect spin								
9	0.505	31.6	0	18 up	236	59 81	0.24	$\frac{3}{4}$, 1, $1\frac{1}{2}$, $2\frac{1}{2}$, 4
10	0.585	31.6	0	18 up	236	59 81	0.24	$\frac{1}{2}$, $\frac{3}{4}$, 1, [c]1, 1, $1\frac{1}{2}$, 2
11	0.650	31.6	0	18 up	236	59 81	0.24	$\frac{1}{2}$, $\frac{3}{4}$, 1, 1, 1, $1\frac{1}{2}$, 2
12	0.650	31.6	0	18 up	236	59 81	0.24	[c]1, [c]1, [c]1, [c]$1\frac{1}{2}$, [c]$1\frac{1}{2}$
Inverted spins to pilot's right								
10	0.585	31.6	Right 0 Left 55	[d]5 up	257	56 68	0.24	>$2\frac{1}{2}$, >$3\frac{1}{4}$
11	0.650	31.6	Right 0 Left 55	[d]5 up	257	56 68	0.24	[e]$1\frac{1}{2}$, [e]$1\frac{1}{2}$, [e]2, [e]$2\frac{1}{4}$

[a]Flat-type parachute, laid-out-flat diameter given.

[b]Based on laid-out-flat diameter.

[c]Parachute jerked model inverted.

[d]Control deflections are with respect to the ground.

[e]After recovery the flaperons cause the model to roll in a steep dive.

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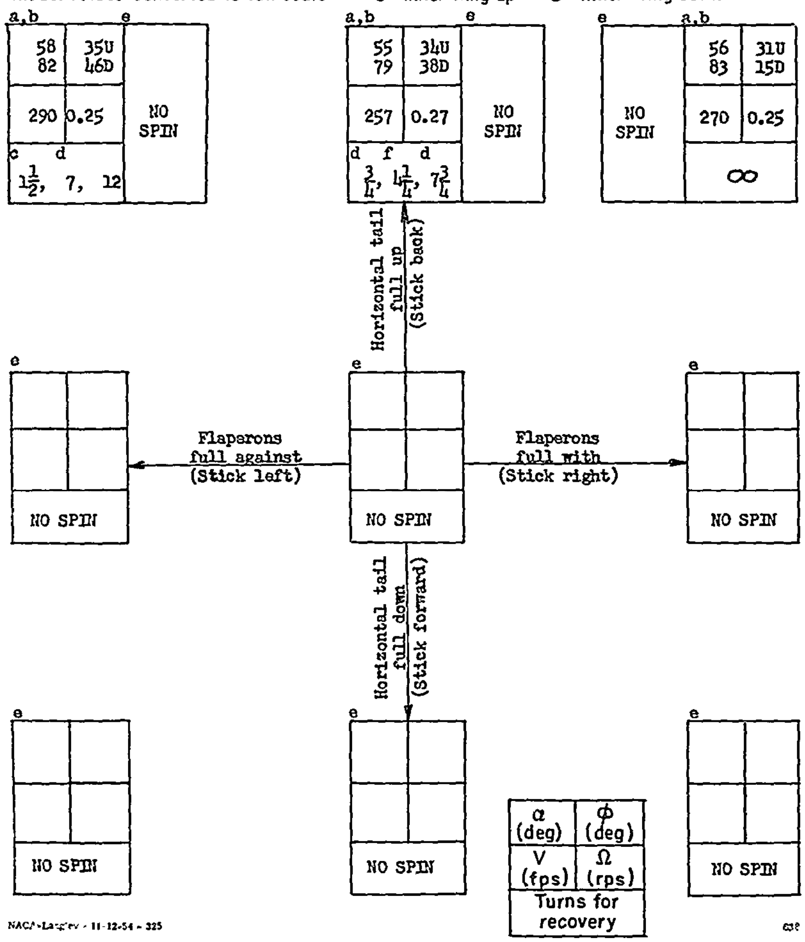
CHART 1.–SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by full rudder reversal unless otherwise noted (recovery attempted from, and steady-spin data presented for, rudder-full-with spins)]

Airplane	Attitude	Direction	Loading (see table II) No. 1	
F11F-1	Erect	Right		
Slats Closed	Flaps Up	Center-of-gravity position 25.6 percent	Altitude 25,000 ft.	

Model values converted to full scale U–inner wing up D–inner wing down



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[a]Oscillatory in roll and yaw, range of values given.
[b]Spins only for short duration (approximate 10 to 15 turns) before oscillates out of the spin.
[c]After recovery starts rotating in opposite direction.
[d]Rolls rapidly about X-axis after recovery.
[e]Oscillates out of the spin and may roll very rapidly about the X-axis.
[f]Recovers in a dive.
[g]Recovery attempted by simultaneously deflecting the rudder to full against the spin and the horizontal tail to full down (stick forward).
[h]Recovers in an inverted glide.
[i]Visual estimate.
[j]After recovery, appears to start into an inverted spin.
[k]Rolls into an inverted glide and then rolls rapidly about X-axis
[l]Enters an erect glide.
[m]Wandering spin.
[n]Recovery attempted by neutralizing the rudder.
[o]Recoveries attempted by deflecting the rudder to only 2/3 against the spin.

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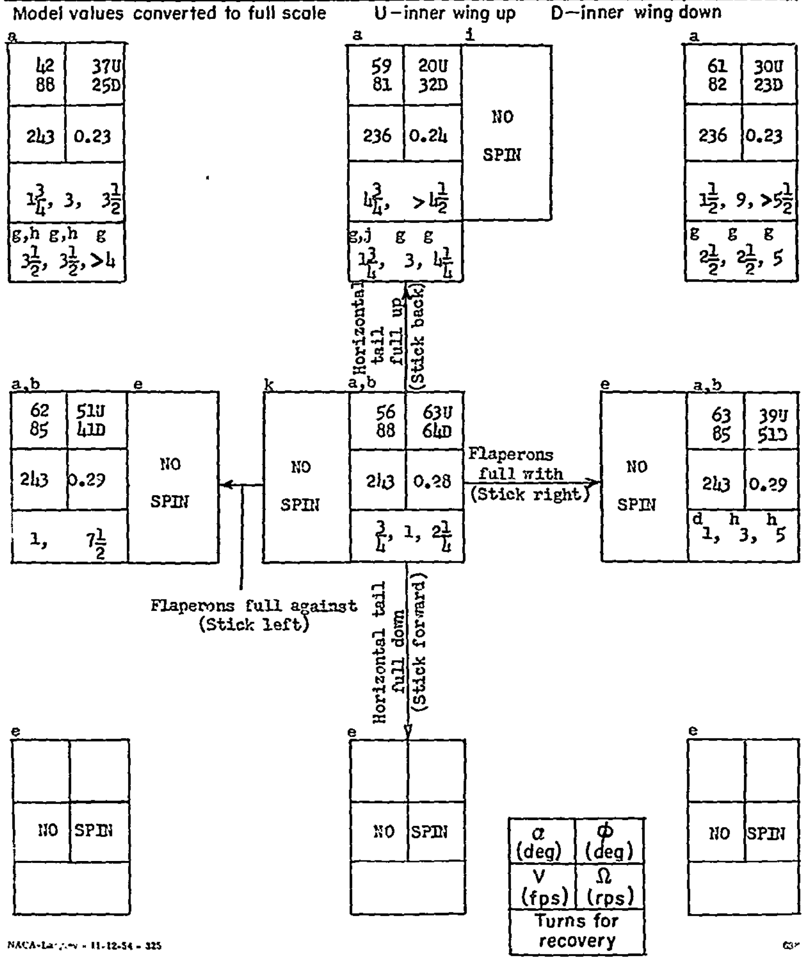
CHART 2.–SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by full rudder reversal unless otherwise noted (recovery attempted from, and steady-spin data presented for, rudder-full-with spins)]

Airplane	Attitude	Direction	Loading (see table II) No. 2	
F11F-1	Erect	Right		
Slats Closed	Flaps Up	Center-of-gravity 29.9 percent	Altitude 25,000 ft.	

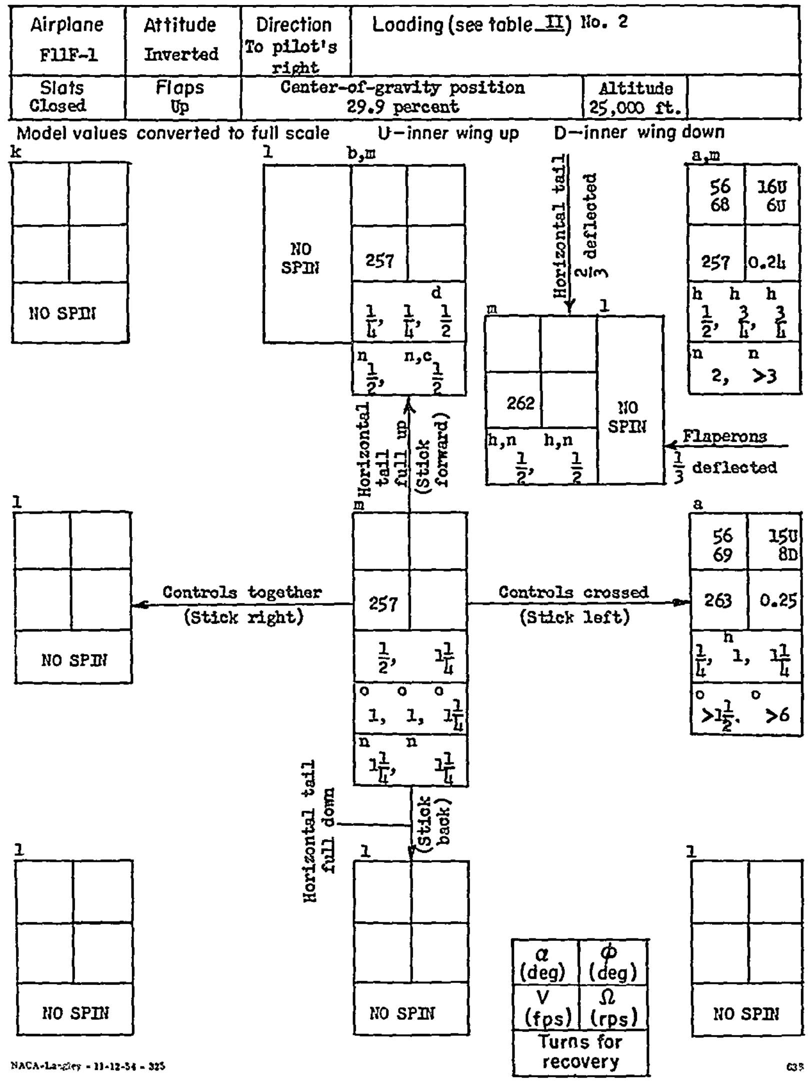
Model values converted to full scale U–inner wing up D–inner wing down



[a]Oscillatory in roll and yaw, range of values given.
[b]Spins only for short duration (approximate 10 to 15 turns) before oscillates out of the spin.
[c]After recovery starts rotating in opposite direction.
[d]Rolls rapidly about X-axis after recovery.
[e]Oscillates out of the spin and may roll very rapidly about the X-axis.
[f]Recovers in a dive.
[g]Recovery attempted by simultaneously deflecting the rudder to full against the spin and the horizontal tail to full down (stick forward).
[h]Recovers in an inverted glide.
[i]Visual estimate.
[j]After recovery, appears to start into an inverted spin.
[k]Rolls into an inverted glide and then rolls rapidly about X-axis
[l]Enters an erect glide.
[m]Wandering spin.
[n]Recovery attempted by neutralizing the rudder.
[o]Recoveries attempted by deflecting the rudder to only 2/3 against the spin.

CHART 3.–SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by full rudder reversal unless otherwise noted (recovery attempted from, and steady-spin data presented for, rudder-full-with spins)]



[a]Oscillatory in roll and yaw, range of values given.
[b]Spins only for short duration (approximate 10 to 15 turns) before oscillates out of the spin.
[c]After recovery starts rotating in opposite direction.
[d]Rolls rapidly about X-axis after recovery.
[e]Oscillates out of the spin and may roll very rapidly about the X-axis.
[f]Recovers in a dive.
[g]Recovery attempted by simultaneously deflecting the rudder to full against the spin and the horizontal tail to full down (stick forward).
[h]Recovers in an inverted glide.
[i]Visual estimate.
[j]After recovery, appears to start into an inverted spin.
[k]Rolls into an inverted glide and then rolls rapidly about X-axis
[l]Enters an erect glide.
[m]Wandering spin.
[n]Recovery attempted by neutralizing the rudder.
[o]Recoveries attempted by deflecting the rudder to only 2/3 against the spin.

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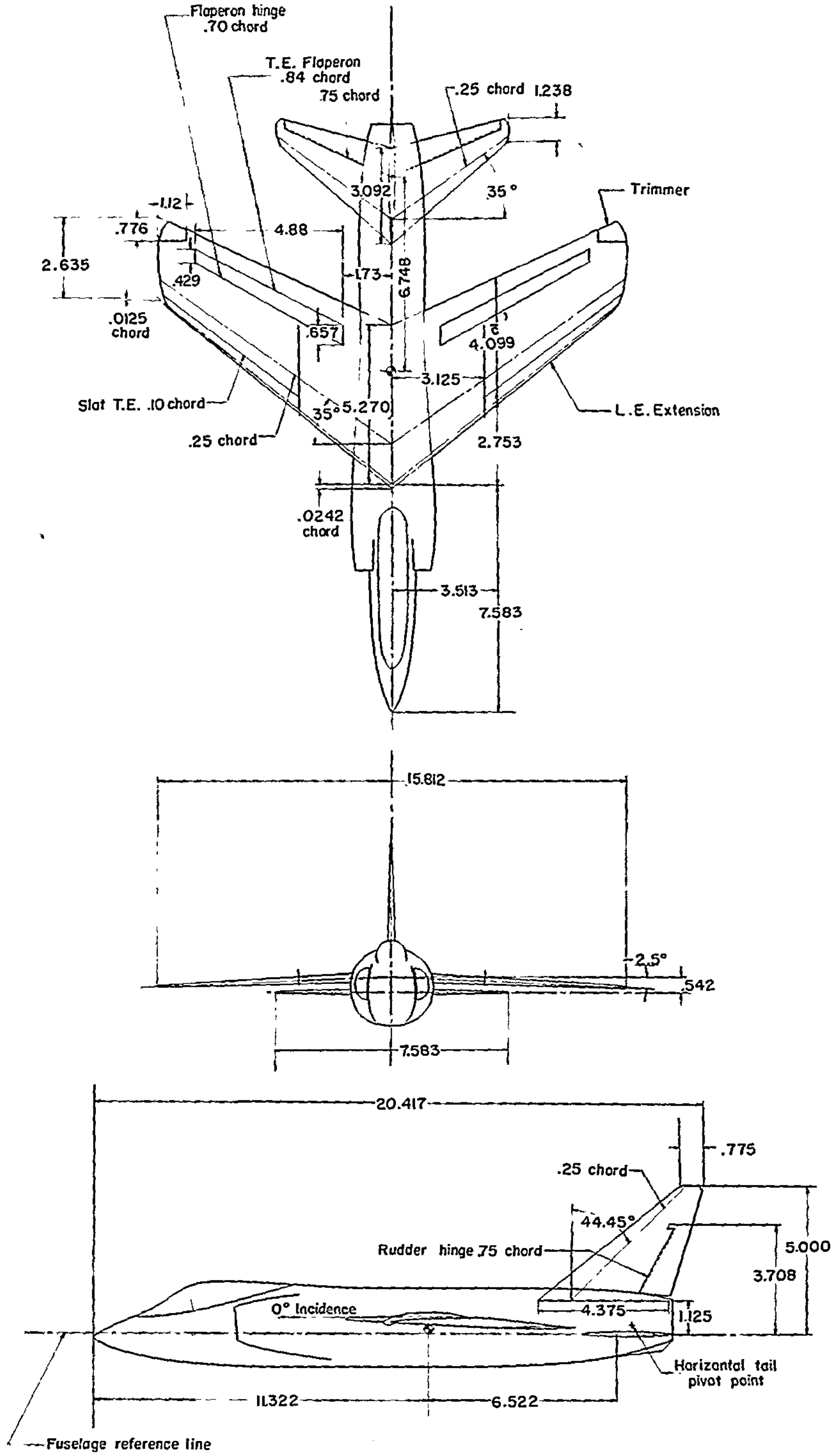

Figure 1.- Three-view drawing of the 1/24-scale model of the Grumman F11F-1 airplane as tested in the Langley 20-foot free-spinning tunnel. Dimensions are model values in inches. Center-of-gravity position shown is 24 percent mean aerodynamic chord.

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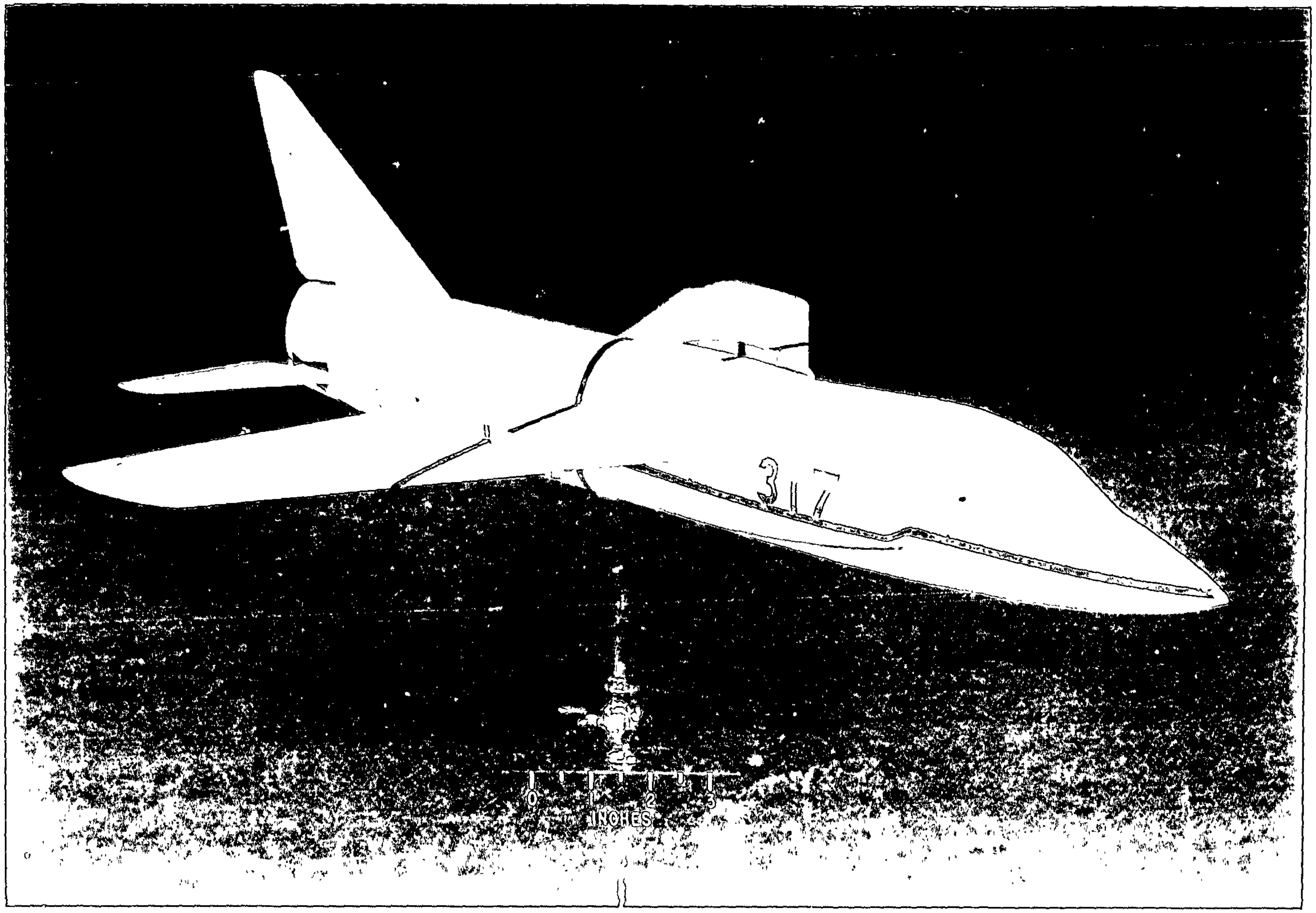

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Figure 2.- Photograph of the Grumman F11F-1 airplane model as tested in the Langley 20-foot free-spinning tunnel.

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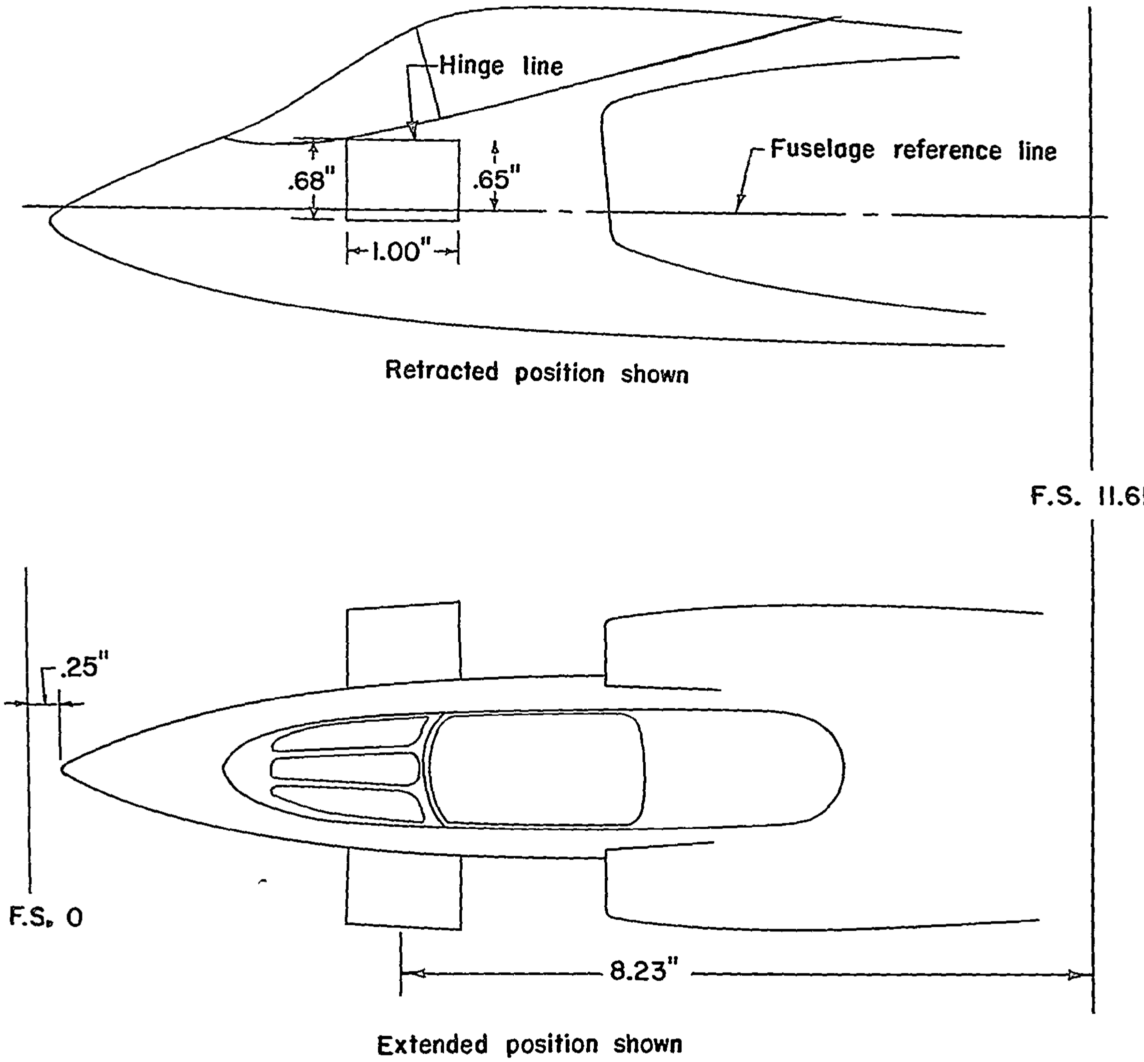

Figure 3.- Sketch showing position of canards tested on a 1/24-scale model of the Grumman F11F-1 airplane. Area of canard shown is 2.19 percent of wing area. Dimensions are model values.

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